Miniature Size Hermetically Sealed Lithium Rechargeable Battery with Liquid Siloxane Electrolyte for Implantable Medical Applications

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Abstract

Quallion LLC has developed a cylindrical miniature size battery with siloxane electrolyte for implantable medical applications. The battery consists of a Ni-based cathode, graphite anode and proprietary liquid siloxane electrolyte. A special design of the jellyroll configuration and battery electrode helped achieve small volumes and high power characteristics. These miniature batteries with siloxane electrolyte showed good cycle and calendar life. More than 95% of the initial capacity was retained after 500 continuous cycles at body temperature.

Introduction

Many great strides have been made in the medical electronics field in the last three decades. Devices such as pacemakers, insulin pumps, and pain management devices have extended or improved the lives of millions of people. [1] The implantable power source for such devices should be small, long-lasting, and safe while having high energy density and total hermeticity.

Lithium ion batteries are currently the technology of choice for these implantable power sources since it combines long cycle life and high energy density. However, the ideal implantable battery technology should also exhibit a calendar life exceeding 10 years. These issues and their solutions are addressed by a new electrolyte system.

Siloxane materials are non-flammable and non-toxic. Therefore, this material is extremely safe for the body. Quallion LLC developed a miniature battery with environmentally friendly liquid siloxane electrolyte and organoborate salts contained in a new thin hermetic packaging technology. The feasibility of this siloxane technology was demonstrated with Argonne National Laboratory and the University of Wisconsin under the ATP program.

Miniature Battery Mechanical Design

The miniature size of the battery was achieved through some manufacturing process developments. The mechanical design was built upon an initial development of the idea [2, 3] in which a feedthrough pin is welded to the inner end of the positive electrode, thereby providing physical and electrical connections. In addition, the pin extends through the battery case end-cap and functions as one of the battery terminals. The battery case itself generally functions as the other battery terminal. The benefits of this feedthrough are as follows.

1) Spirally wound jelly roll can be manufactured.
2) The energy density and rate capability are increased by minimizing battery head space and maximizing the electrode area.
3) Heat can be released through the pin.

The miniature size battery was built with a $LiNiCoAlO_2$/graphite electrodes and a siloxane electrolyte of 0.8 M – organoborate salt.

Battery Performance

Figure 1 shows the cycling performance of a miniature battery using siloxane electrolyte and organoborate salt. The results show great improvements upon typical lithium ion cells as the capacity retention exceeds 95% after 500 cycles at C/5 rate.

From this cycle life test, we can also predict future cycling performance by using the capacity fade model reported by Jungst et al. [3]. The linear decrease in the cell capacity (vs. log of the cycle number) observed for the first 300 cycles allows us to predict a 13-year calendar life with 70% capacity retention.

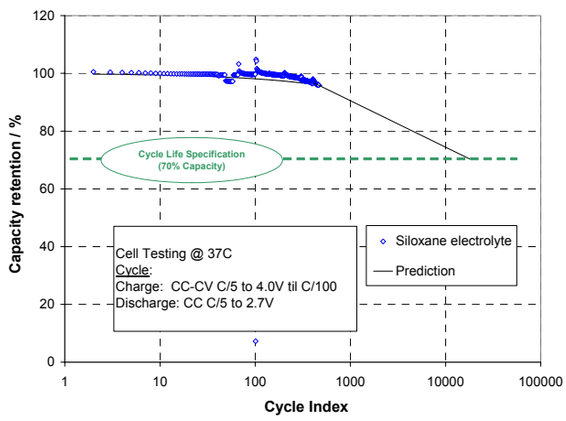

Figure 1. Cycling performance of miniature size cells at C/5 rate and 100% depth of discharge (DOD)

References

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